NASA SBIR/STTR Technologies

Z1.01-9707 - High-Efficiency Rad-Hard Ultra-Thin Si Photovoltaic Cell Technology for Space

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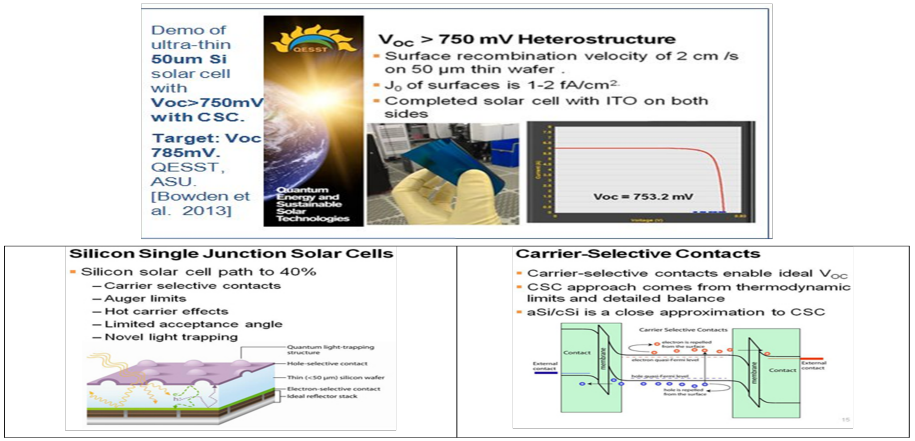
Identification and Significance of Innovation

Improvements to solar cell efficiency are critical for future NASA space missions. Several issues must be addressed for high efficiency Si devices for space. The Ultra-Thin (UT) structure and device optimization requires computer modeling tools for analysis, and optimization, which include models of novel physics used. The key innovations proposed include: (i)Novel, ultra-thin, flexible, low cost Si based photovoltaic cell technology that combines enhanced light trapping (LT) and absorption, with carrier selective contacts (CSC), and multiple exciton generation (MEG) to produce estimated efficiency of 36%+ for this ultra-thin (UT) solar cell technology; (ii) New, physics-based computational tools for modeling and optimization of such UT photovoltaic nanostructures and their validation against experimental data; (iii) Radiation hardness of UT Si PV technology will be engineered; (iv) Demonstration of efficient, manufacturable UT Si PV technology for space.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)



A path to 40% efficient Silicon single junction solar cell for space(top). New effects used to enhance efficiency(left) [Honsberg, 2013]. Schematic of a carrier selective contact implemented by surface inversion (right)[Bouden 2013].

Technical Objectives and Work Plan

The overall, far-reaching objectives of this effort are twofold:
- Design, Fabricate, Evaluate, and deliver better, more efficient, lightweight, flexible, low cost photovoltaic solar cells for the NASA space missions.
- Develop and provide reliable, validated computational tools for assessment, design, and optimization of novel UT solar cell technologies with LT, CSC and MEG, and PV devices for NASA applications

In this project, CFDRC and its partners will adopt a proven strategy for the development of new technologies: a combined theoretical/numerical and experimental approach.
- CFD Research Corporation (CFDRC) will use its multi-year experience and expertise in nanostructured PV cell device physics, analysis, and technology computer-aided-design (TCAD), and its own advanced research software (NanoTCAD) for physical three-dimensional (3D) simulations of semiconductor devices (including nano-scale optoelectronic devices) for exploration, analysis, optimization, and development of the novel nanostructured device concepts and complete UT PV cell simulation (Figure 2).
- The subcontractor, Arizona State University (ASU), will support CFDRC by design, growth, fabrication and testing of both standard and UT enhanced photovoltaic devices. ASU will perform the initial UT design verification (highly textured surfaces, CSC).

NASA Applications

The low costs and high manufacturability of UT Si PV cells will remove the solar array as a cost driver, while radiation tolerance will lead to more robust space systems. The new modeling and simulation tools for UT Si PV technologies, employing new physical effects will help NASA to: a) assess technologies, devices, and materials for new photovoltaic solar cells; b) better evaluate the performance and radiation response at design stage; c) reduce the amount of testing cost and time.

Non-NASA Applications

All satellites, military and commercial, suffer from solar cell degradation due to the effects of radiation. The higher efficiency of the novel rad-hard UT Si solar cells will reduce the weight of the solar array, maintaining the power generation requirements of satellite system.
Low costs of UT Si PVs allow these PV cells to compete for terrestrial applications.

Firm Contacts

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